A NEW SUBSPECIES OF *CICINDELA BELLISSIMA* FROM NORTHWESTERN WASHINGTON (COLEOPTERA: CICINDELIDAE)

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ABSTRACT

A new subspecies of *Cicindela bellissima, C. b. frechini,* is described from *WA. Clallam Co., Mukkah Bay.* It is characterized by being smaller than the nominate subspecies and in having a statistically significantly narrower humeral lunule.

INTRODUCTION

In the course of a general review of tiger beetles of the Pacific Northwest, I found that *Cicindela bellissima* from northwestern Clallam County, Washington, appeared to be distinctly smaller than series from southwestern Washington and coastal Oregon. The results of a discriminant analysis of a series of 120 specimens have convinced me that the Clallam County population deserves taxonomic recognition.

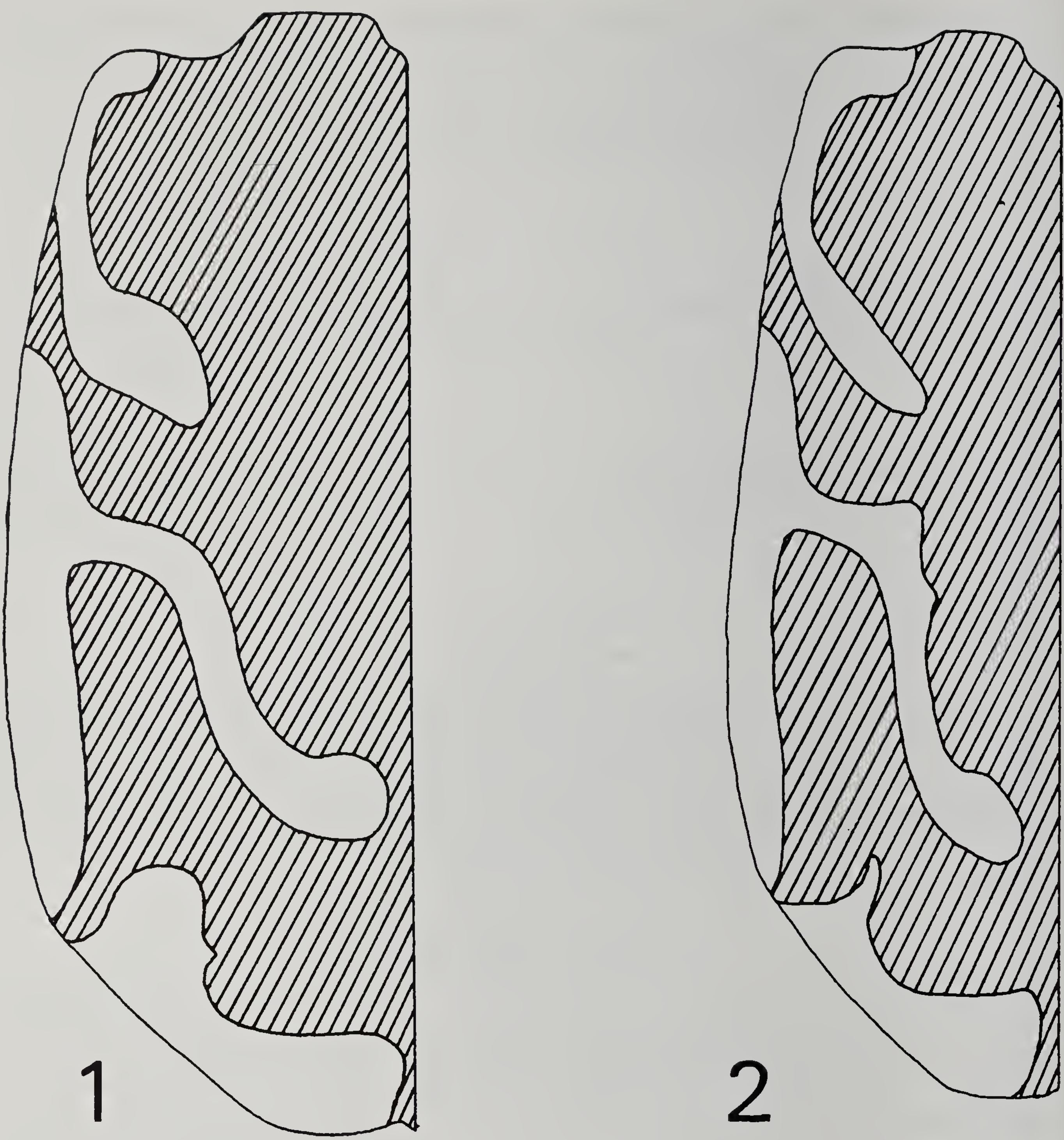
MATERIALS AND METHODS

I examined specimens from several collections including the lectotype of *C. b. bellissima* in the American Museum of Natural History, New York. I took 7 measurements of each of 120 specimens using a calibrated ocular micrometer. Specimens measured are from my personal collection and from the Melville H. Hatch Collection, now in the Museum of Entomology, Oregon State University. Measurements were used for discriminant analysis using SPSS (Statistical Package for the Social Sciences) procedures as described by Nie (1975). Discriminant analysis was performed using SPSS version 7.0 as maintained on the University of Washington Academic Computer Center Operating System.

Specimens from the following localities were measured:

1. WA. Clallam Co., Mukkah Bay – 17 males, 19 females
2. WA. Pacific Co., several localities – 15 males, 11 females
3. OR. Tillamook and Coos Cos., several localities – 8 males, 7 females
4. OR. Curry Co., mouth Pistol River

For the study of geographical variation of *C. bellissima,* I measured the following variables: 1, length of left elytron from apex of scutellum; 2, greatest breadth of left elytron; 3, greatest breadth of head (across eyes); 4, length of labrum at midline, including tooth; 5, basal breadth of labrum; 6, breadth of distal end of humeral lunule; 7, distance between distal end of humeral lunule and bend of middle band (point of closest proximity). Ranges, means, and standard deviations are presented in Table 1.



Figs. 1-2, elytral maculation pattern: 1) *C. b. bellissima*; 2) *C. b. frechini*. X11.

Cicindela (Cicindela) bellissima frechini Leffler, **new subspecies**
(Figs. 1-2)

Diagnosis.—The new subspecies differs from *C. b. bellissima* in the narrower posterior breadth of the humeral lunule, a better than 97% separation for both sexes. Discriminant analysis gives 89.7% separation in males for 7 variables and 90.7% in females.

Type locality.—Washington. Clallam Co., Mukkah Bay.

Holotype.—Male. Washington. Clallam Co., Mukkah Bay, 13-IX-1977, AMNH type collection, S. R. Leffler, collector. I have deposited the holotype and allotype in the American Museum of Natural History because the type series of *C. b. bellissima* Leng is preserved there. Having both types in the same repository may facilitate future studies. With the types I have deposited a copy of my field notes and a set of habitat photographs.

Allotype.—Female. Same data as holotype.

Paratypes.—Four paratypes each to the following individuals: Mr. V. G. Clifford, Graham, Washington; Mr. D. R. Frechin, Seattle, Washington; Mr. W. Johnson, Minneapolis, Minnesota. Two paratypes each to the following institutions and individuals: National Museum of Natural History, Washington, DC; University of Idaho, Moscow, Idaho; Washington State University, Pullman, Washington; Dr. F. M. Beer, Corvallis, Oregon; Mr. Russell Biggam, Moscow, Idaho; and Mr. R. L. Huber, St. Paul, Minnesota. The remaining 11 paratypes as well as 5 larvae are in my personal collection.

Etymology.—I dedicate this subspecies to Mr. Donald R. Frechin, Seattle, Washington.

Description.—Head: Labrum yellowish-white with median portion of anterior margin black, single row of subapical setae, unidentate; antennal scape cupreous-tinged metallic green, glabrous except for four subapical sensory setae; clypeus and genae glabrous; frons and vertex sparsely setose. *Thorax*: Pronotum setose laterally and on posterior and anterior part of disc except at midline, sculpture finely vermiculate; propleuron, proepimeron, procoxa, mesepimeron, mesepisternum, mesocoxa, and anterolateral portion of metasternum with dense, erect, long setae; metacoxa sparsely anteriorly setose; prosternum, mesosternum, and remainder of metasternum and metacoxa glabrous. *Abdomen*: venter covered with semidecumbent setae, densest laterally, median portion of two posteriormost sternites glabrous. *Elytron*: Male, gradually wider from base toward apex, widest part at apical fifth; female, gradually wider from base to apical third, then nearly parallel to apical fifth and rapidly tapered to apex; both sexes with small sutural spines, fine, blunt microserrae, and submarginal apical setae; sculpture consisting of shallow punctae, with sparsely-occurring punctal confluence, interpunctal area finely micropunctate resulting in dull lustre; maculation as in Fig. 2. *Color*: head and margins of pronotum metallic green with blue-violet reflections and cupreous concentrated along midline of frons, vertex, occiput, and medial margins of eyes and anterior and posterior pronotal margins; discal callosities of pronotum cupreous becoming brassy laterally; genae and entire venter metallic blue-green with violet reflections; propleuron brassy-cupreous, becoming green anteriorly and posteriorly; elytral punctae dark blue-violet margined with green, interpunctal area cupreous (differences in breadth of green of punctal margins resulting in brown to green tone of elytra: broad green margin producing predominantly green elytra, reduced green and expanded cupreous producing predominantly brown elytra); elytral suture metallic cupreous; legs metallic green with cupreous and brassy reflections, strongest on tibiae.

Comparisons with C. b. bellissima.—Discriminant analysis showed that variables 6, 4, 2, and 3, in that order, with F-values of 2.0 or greater, are the most discriminating in distinguishing males of the two subspecies, and 6, 5, and 1, with F-values of 2.0 or greater, for females. The discriminant analysis resulted in 89.7% of the males and 90.7% of the females being assigned to the proper subspecies.

Application of the 97% rule of Amadon (1949) to variable 6 reveals that 97% of both sexes of *frechini* are separable from 97% of *bellissima* based on this variable.

Maser (1973:73) outlined color variation in *C. b. bellissima*. Cazier (1939:28) reported black individuals. Maser mentioned no black specimens and I have not seen a single black individual or even one that is dark brown in over 200 examined from several museum collections. If black individuals do indeed exist, they must be rare. Maser stated that specimens from the southern portion of the subspecies' range averaged greater numbers with green suffusion on the head and pronotum, although such variants did not dominate the population. Table 2 presents a summary of color variation of small series from three localities. The results show that of the 19 *frechini* (sexes pooled) 21.1% are completely bronzy-brown dorsally, 42.1% have

TABLE 1. Localities and statistics of *C. bellissima* measured. See text for identifications of localities and characters here referred to by number. Values are limits of observed range followed in parentheses by the arithmetic mean and standard deviation.

Character	Sex	Locality 1	males—15 females—19	Locality 2	males—15 females—11	Locality 3	males—8 females—7	Locality 4	males—18 females—17
1	m	6.50-7.43	(6.98 + .28)	6.79-7.60	(7.22 + .25)	6.79-7.84	(7.31 + .40)	6.92-9.11	(7.42 + .50)
	f	6.89-7.90	(7.35 + .31)	6.63-7.99	(7.30 + .47)	7.16-8.53	(7.91 + .41)	7.41-8.39	(7.78 + .32)
2	m	2.03-2.63	(2.29 + .19)	2.02-2.71	(2.43 + .23)	2.43-2.84	(2.65 + .15)	2.30-2.73	(2.57 + .16)
	f	2.30-2.93	(2.65 + .16)	2.30-2.90	(2.66 + .19)	2.60-3.18	(2.89 + .21)	2.50-3.25	(2.88 + .20)
3	m	2.70-3.18	(2.96 + .13)	2.82-3.12	(2.98 + .10)	2.84-3.25	(3.02 + .16)	2.95-3.25	(3.07 + .10)
	f	2.75-3.38	(3.11 + .15)	2.87-3.36	(3.10 + .15)	3.14-3.39	(3.28 + .09)	3.08-3.89	(3.36 + .24)
4	m	0.68-0.95	(0.80 + .07)	0.80-0.98	(0.89 + .07)	0.78-0.98	(0.84 + .06)	0.77-1.06	(0.87 + .07)
	f	0.68-0.99	(0.85 + .11)	0.81-0.96	(0.87 + .05)	0.81-1.06	(0.91 + .10)	0.92-1.07	(0.97 + .05)
5	m	1.74-2.11	(1.97 + .10)	1.83-2.28	(2.04 + .11)	1.77-2.17	(2.07 + .09)	1.89-2.30	(2.05 + .13)
	f	1.78-2.16	(2.01 + .11)	1.96-2.30	(2.08 + .10)	1.89-2.43	(2.22 + .19)	2.12-2.43	(2.25 + .11)
6	m	0.28-0.54	(0.41 + .07)	0.41-0.78	(0.54 + .12)	0.47-0.81	(0.61 + .11)	0.43-0.80	(0.60 + .10)
	f	0.29-0.54	(0.40 + .06)	0.42-0.75	(0.53 + .08)	0.43-0.83	(0.60 + .12)	0.51-0.84	(0.59 + .09)
7	m	0.20-0.54	(0.37 + .11)	0.13-0.53	(0.28 + .13)	0.11-0.41	(0.31 + .10)	0.17-0.70	(0.39 + .18)
	f	0.28-0.78	(0.44 + .12)	0.15-0.53	(0.34 + .13)	0.25-0.41	(0.35 + .05)	0.36-0.81	(0.54 + .14)

green suffusion on the head and pronotum, and 36.8% are uniformly green or blue-green dorsally. Of the 27 *bellissima* (sexes pooled), the same proportions are respectively: 18.5, 7.4, and 70.4%, with 3.7% uniformly blue dorsally. These data show that there is a higher proportion of brown individuals of *frechini* than *bellissima*.

Habitat Description

Maser (1973) described habitat characteristics of *C. b. bellissima*. *C. b. frechini* also inhabits foredune saddles and deflation plains (terminology of Wiedemann *et al.* 1969). Maser stated that much of the dune area of the Oregon coast has been stabilized by introduction of binding vegetation, particularly European beach grass, *Ammophila arenaria* (Linnaeus). The Mukkah Bay deflation plains have either not been so extensively planted or the binding vegetation has as yet only covered the inland edges. The dune saddles where the beetles are most abundant are devoid of vegetation, and beetles are found only around the edges of the deflation plain where there is sparse growth of *Agoseris, Fragaria, Poa,* and *Polygonum*. I saw one beetle on the beach strand line under seaweed.

To Maser's data on activity time I add the following information. On 13-IX-1977, I began my observations at 0950 PDT: air temperature, 16.7° C., 1 m. above ground surface. I saw the first beetles at 1020: air temperature, 20.0° C.; dry sand surface temperature, 24.4° C. By 1200, the beetles were abundant, perhaps 50/ 100 m.^{2}. Saddle temperatures were higher than ambient air temperature because of heat radiation from the sand and blockage of ocean breezes by the dunes: 1200 hrs. air temperature, 24.4° C.; sand surface temperature in saddle, 28.9° C.

I collected three 2nd-instar larvae (L2) 10-IX-1976 and one L2 and one L3 13-IX-1977 on a 4X3X1 m. sand mound (both collections from the same mound) with a sparse growth of *Ammophila* and *Fragaria*. In 1977, I found 8 burrows on this mound. Burrow diameters suggested 5 LL2 and three LL3. Larvae were found down to a depth of 20 cm.; one excavated in 1976 was at a depth of 12.7 cm. Sand was wet below a depth of 7.6 cm. in 1976 and 6.0 cm. in 1977.

Other dune inhabitants were immature wolf spiders (*Pardosa* sp.), one of which I saw enter a tiger beetle larval burrow, amphipods, adult *Nebria diversa* (Carabidae), adult *Cafius* sp. (Staphylinidae), adult *Eleodes scabrosa* (Tenebrionidae), teneral adult *Helcomyza mirabilis* (Diptera: Helcomyzidae), and *Lasius niger* (Formicidae) including not-yet-volant alates. Various stages of any of these invertebrates could presumably serve as food for the beetles and their larvae, although I never actually observed feeding. A few *Cicindela oregona* were present in the more vegetated portions of the deflation plain where there was more humus.

A note on the locality name: although the locality is part of the Makah Indian Reservation, the correct spelling for the name of the bay is Mukkah.

Other Localities

Dr. D. L. Pearson collected specimens *WA. Clallam Co., Neah Bay*. The beach within the corporate limits of Neah Bay has dunes along the southern margin, but the entire beach is only about 100 m. wide (north to

TABLE 2. Dorsal color variation in population samples of *Cicindela bellissima*. Numbers refer to the number of individuals showing each character-state, followed in parentheses by the percentage of the entire sample of each population (sexes separate).

Locality and sex		N	dorsum uniformly bronze-brown	head and pronotum with green suffusion; elytra brown	dorsum uniformly green or blue-green	dorsum uniformly blue
1. WA. Clallam Co., Mukkah Bay	Males	5	1 (20.0%)	2 (40.0%)	2 (40.0%)	0 (0.0%)
	Females	14	3 (21.4%)	6 (42.9%)	5 (35.7%)	0 (0.0%)
2. WA. Pacific Co., Long Beach	Males	12	3 (25.0%)	1 (8.3%)	8 (66.7%)	0 (0.0%)
	Females	9	0 (0.0%)	0 (0.0%)	8 (88.9%)	1 (11.1%)
3. OR. Curry Co., mouth Pistol River	Males	4	2 (50.0%)	1 (25.0%)	1 (25.0%)	0 (0.0%)
	Females	2	0 (0.0%)	0 (0.0%)	2 (100.0%)	0 (0.0%)

south) and has been extensively disturbed by human activities. I visited dunes near the town of Clallam Bay, 27 km. east of Neah Bay, but these were gravelly and supported only *Cicindela oregona*. There is no other dune development either along the Straits of Juan de Fuca, the southwestern shore of Vancouver Island, or along the Pacific shore between Mukkah Bay and Moclips. Apparently, then, *C. b. frechini* is geographically restricted to the vicinity of Mukkah Bay and Neah Bay.

Geological History

Knowledge of the historical geology of the west coast of the Olympic Peninsula is adequate in determining the earliest possible time when the ancestral stock of *C. b. frechini* might have first occupied its present range. Habitat along the coast is now suitable for *C. bellissima* only in the vicinity of Cape Flattery, Clallam County, and south from Moclips, Grays Harbor County. The remaining coastline, a distance of about 120 km., consists of forested terraces, steep cliffs, and headlands. Heusser (1972) stated that the portion between the Queets and Hoh Rivers, now a sea cliff, about midway between Cape Flattery and Moclips, was an alluvial plain whose present stratigraphy suggests the presence of foredunes and deflation plains that at the close of the Pleistocene may have supported populations of *C. bellissima*.

The Juan de Fuca lobe of the Cordilleran ice sheet completely covered the northern and northwestern portions of the Olympic Peninsula, to a depth of 600-815 m. 20 km. southeast of Cape Flattery (Heusser 1973a), and extended south along the coast to a point 2.4 km. south of Ruby Beach at the mouth of the Soleduck River, 43 km. south of Cape Flattery. Presence of the ice sheet meant that habitat for *C. bellissima* was unavailable within about 40 km. of Cape Flattery. Wastage of the Juan de Fuca lobe at its terminus began before about 14,460 years before present (yBP), the last remnants disappearing by 9,380 + 180 yBP (Heusser 1973a). Recession of the extensive lobes from the Olympic Mountains ice cap that filled the coastal river valleys began before 15,600 yBp, and the last remnants of the Bogachiel glacier had disappeared by 6,500 yBP (Heusser 1973b).

Determination of July isotherms based on palynological studies show that temperatures may have been too cold for *C. bellissima* even in non-glaciated areas of the northwestern Olympic Peninsula at the time of ice sheet recession. A cautionary note: temperature reconstructions are based on comparisons with *modern* plant assemblages which may not always be completely analogous to Pleistocene assemblages. I calculated July isotherms for Quillayute, south-southeast of Cape Flattery, and for Astoria and Gold Beach, Oregon, the latter being localities inhabited by *C. b. bellissima,* using climatological data for 1970-1974. Mean July isotherms for the three stations are not different at the 95% level of significance and average 15.2° C. Heusser (1973a) stated that July isotherms on the newly deglaciated area were: *c.* 12° C. at 14,000 yBP; 14° C. at 11-13,000 yBP; and 12° C. at 10-11,000 yBP. During Hypsithermal time (3-7,000 yBP) the isotherm was 17° C., with annual precipitation only 760 mm, compared with 2-3,000 mm at present. Adult *C. bellissima* are active mainly from April to mid-June and again after August. Some senescent and teneral adults are present in July, but this is not the optimal activity period. Early postglacial July isotherms as given by Heusser (1973a) are equivalent to present day late-May temperatures. Temperature depression of 3° C. would result, during early Postglacial time, in a spring emergence isotherm of 4° C. (presently 7.3° C.) and 10-12° C. (13.3-15.2° C. at present) for August-September activity.

I conclude that temperatures were too low in late Glacial and early Postglacial times for *C. bellissima* on the northwestern Olympic Peninsula. Ancestral stock of *C. b. frechini* perhaps did not arrive there until the Hypsithermal, possibly arriving from then available habitat between the Queets and Hoh River mouths.

A Plea for Conservation

At a time when human activities are making inroads on natural habitats, attention is being paid to the well-being of wildlife. Habitat destruction in general and collectors exert pressure on insect populations; as an example, I know of at least two cases in the western United States where endemic tiger beetle species or subspecies have been nearly exterminated by overcollecting.

C. b. frechini is abundant at the type locality which is, in turn, of extremely limited extent. Excessive collecting, particularly in the late summer or early spring, before the beetles have oviposited, could decimate the population, or, worse, exterminate it. I do not plan to collect more specimens from the locality and I request that other collectors limit their sampling as well.

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